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Foreign Technology Division
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EDITED TRANSLATION

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В в	*В в*	V, v	Т т	*Т т*	T, t
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Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

STUDY OF THE PHYSICOCHEMICAL CHARACTERISTICS OF A POWERFUL AEROSOL WAVE

K. P. Kutsenogiy, V. I. Makarov,
Yu. F. Chankin, V. M. Sakharov,
and G. N. Zagulyayev

The basic physicochemical characteristics which determine the effectiveness of using insecticide aerosols as insect repellants are the dispersed composition of the aerosols employed, the dose (the integral of the concentration of toxic chemical in the aerosol per unit time), and the deposition density.

This paper describes the methodology and results of determining the characteristics listed above directly during experimental-production tests with a powerful aerosol generator [MAG] (МАГа) [5] at distances of several kilometers from the line of travel of the generator.

The investigation methodology reduced to the following: an MAG, moving approximately perpendicular to the wind, produced an aerosol wave extending 3-5 km which was carried by the wind over the terrain being treated. Aerosol sampling points were set up at various distances from the wave formation line at approximately its center. Sampling was done throughout the time the wave existed at the observation point. Test samples were taken by sucking the aerosol at a constant rate (100 l/min) through AFA-KhA-18 filters

mounted in a special assembly. The assembly design provided for two filters one behind the other which permitted determination of the coefficient of passage through the first filter, based on the amount of substance settling onto each filter.

The dispersed composition was determined by selecting the samples from batteries of five identical cascade impactors each of which nad four cascades similar to the May impactor [6] with nozzles having rectangular cross sections of 9 x 19 2.8 x 16, 1.7 x 15 or 1 x 10 mm. Behind the fourth cascade was a stage consisting of Petryanov analytical filter material [FPA] (ФПА) on which the particles remaining after the first four cascades were trapped. With an impactor aspiration rate of 20 l/min and an efficiency of 50%, particles with the following diameters were precipitated: 20 μm in the first cascade, 5.8 μm in the second cascade, 3.7 μm in the third cascade, and 1.8 μm in the fourth cascade. These values were determined from the experimental data of Ranz and Wong [7]. For particles precipitating on the fifth stage, the effective mean mass diameter, determined by the countable-weight method, was about 1 μm.

A rotating fan having five channels corresponding to the number of battery impactors insures suction through the cascade impactors. The readings from direct-reading flowmeters having a tapered screw maintained the constancy of the suction. The entire control-measuring system was monitored on the face panel of the fan housing. The current for the electric motor of the fan was supplied by a GSR-3000 generator driven by a "Druzhba" gas engine. The same generator fed a vacuum cleaner used for aspiration through a cartridge equipped with AFA filters. Besides the movable point equipment mentioned above, the experiment also made use of a field laboratory mounted on a ZIL-151 automobile. In addition to the [AFA-KhA] (АФА-ХА) filters and battery of cascade impactors, the lab was fitted with apparatus for the

continuous recording of the concentration and for automatic calculation and determination of the dimensions of the aerosol particles in the range of approximately 0.3-10 μm. The laboratory had a large self-contained suction system, with an output of several cubic meters per minute, and an AB-1/230 generating set [3].

Deposition density is determined by the amount of toxic chemical which precipitates on the 50 × 50 cm glass plates during their exposure throughout the cloud's existence in the vertical and horizontal positions. At the start of the test, slides were placed in the aerosol wave and following exposure in the cloud were examined under a microscope. This procedure established the fact that comparatively large drops (larger than 10 μm in diameter) precipitate onto the glass. Sharp changes in the dimension spectrum of precipitated drops and a withdrawal from the generation line were observed for particles larger than 50 μm. However, the quantitative relationships could not be achieved from these data because of the extremely small number of drops precipitating on the glass, beginning at distances of 1 km and more.

Figure 1 depicts the qualitative picture of the spectrum for drops precipitating onto the glass. The curve of Fig. 1 was obtained by averaging all the drops measured which precipitated horizontally on the exposure glasses regardless of the distance to the MAG travel line.

An evaluation of the amount of substance which precipitates onto the horizontal surface according to the data obtained from microscopic measurements showed that the amount of substance transferred into the aerosol compound which precipitates within 10 km of the wave formation line equals several percent. Concurrent with this, particular significance was attached to the data on the actual composition of the aerosol cloud and the variation in the cloud's dispersability with distance from the generator.

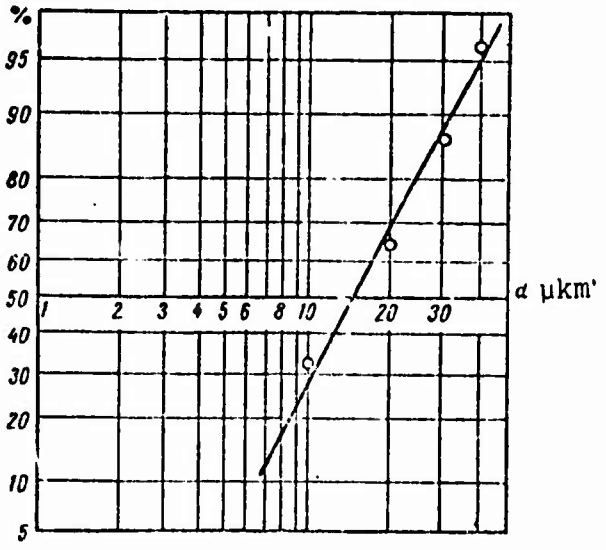

Fig. 1. Dispersed composition of drops precipitating onto horizontal slides. The % content for drops with a diameter larger than that set is along the ordinate axis; the drop diameter (μm) is along the abscissa axis.

Table 1.

x, km		Fraction of toxic chemical (%) stages				
		I	II	III	IV	V
1	10	6	5	5	25	59
3	7	10	11	10	27	42
6	8	7	8	6	25	54

Table 1 gives data for the dispersed composition of the aerosol cloud, obtained from cascade impactors at various distances from the MAG. Processing of the experimental data was accomplished in the following sequence: aerosol samples extracted from the batteries of the cascade impactors were delivered to the laboratory where deposits from the five first, five second, etc. stages were extracted by an organic solvent and then were subjected to chemical analysis. The mass fraction for drops of one size or another was calculated on the basis of the amount of substance observed on the first, second, etc., stages of the cascade impactors. These fractions, expressed as percents, are given in the last five columns of Table 1.

Column one shows the distance x at which the sample was taken; column two shows the number of tests N from which averaging of the data was accomplished. Despite the use of batteries of five impactors, the amount of aerosol precipitating on the first three stages was insignificant and close to the sensitivity of the chemical analysis method. Therefore, the accuracy of the statistics relating to the first three stages was about 50%, and about 15% for the last two stages. It is clear from the data in Table 1 that within the limit of determination accuracy there is no significant difference in the dispersed composition of the aerosol cloud at distances of 1.3 and 6 km.

Detailed microscopic investigations of the deposits on the first two stages of the cascade impactors produced more detailed information as to the dispersed composition for the fraction of particles larger than 5 μm in diameter. For this purpose, the glasses mounted on the first two stages were photographed under a microscope using an MFN-3 microscopic photographic-attachment equipped with a "Zorkiy-4" camera. Each glass was divided into seven photographs so that 35 negatives could be obtained from each stage. Prints measuring 12 x 18 cm were made from them; these were processed using a semiautomatic device built on V. P. D'yachenko's slide rule principle [1]. Our [slide] rule was distinct in that circles rather than tick marks comprised the templates for the measuring categories; the diameters of the circles increased in arithmetic progression. The number of drops for each test usually was not less than 200 for each stage selection. The data from the lot of photographs was grouped according to the distance to the MAG; this was done to calculate the distribution curve for the drops on the basis of size and for the group as a whole. Unification of the data into one series increased the reliability of the results since the total sampling involved at least several thousand particles. The results of processing the data for the

first stage of the cascade impactors by this method are given in Fig. 2. The quantities lying along the coordinate axes correspond in full to those in Fig. 1. The data reflected in Fig. 2 by circles refer to a distance in 1 km intervals; the triangles - 3 km intervals; the squares - in 6 km intervals. Figure 3 gives a similar curve for the impactor second stage. The dispersed composition of the drops is practically without variation with distance for the second stage, while a sharply distinct difference is noticed for drops precipitating on the first stage. Thus, at a distance of 1 km, drops larger than 20 μm comprise 29% of the total number of drops observed on the impactor first stage, while at distances of 3 km and 6 km the fraction of these drops decreases to 12% and 3% respectively. Similarly, for drops larger than 30 μm, the fraction at 1 km is 3% and at 3 km it is 0.5%; at 6 km these drops are practically eliminated. These data reveal that under conditions approximating the MAG test one can anticipate a noticeable loss of toxic chemical due to precipitation, if the aerosol particle diameter is 20-30 μm when the density of the substance they form is close to that of water.

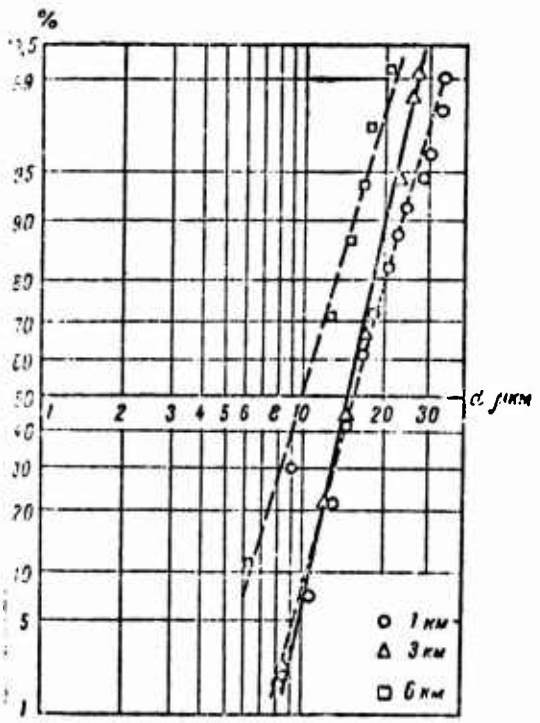

Fig. 2. Dispersed composition for drops precipitating on stage I of the cascade impactor.

Chemical analysis data and the results of microscope measurements showed that at a distance of 1 km or more not more than 5% of the toxic chemical in the aerosol state appears as drops larger than 25 μm; about 90% are less than 15 μm. This clears up the problem as to the reason for the slight deposition densities obtained when evaluating the deposits on slides.

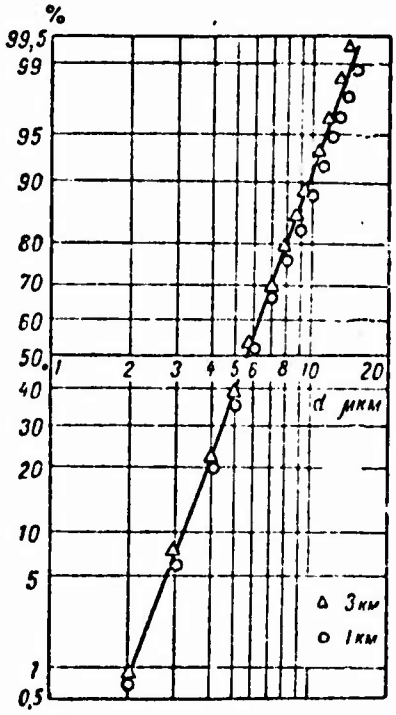

Fig. 3. Dispersed composition for drops precipitating on stage II of the cascade impactor. See Fig. 1 for designations.

Quantitative evaluations of the deposits were conducted through chemical analysis of the toxic chemical which precipitates onto the 50 × 50 cm glass plates. These data are given in Table 2. There is about a 50% accuracy in the values given in Table 2 owing to the insignficant amount of substance in the sample under analysis. Within these accuracy limits it is impossible to speak sufficiently authoritatively about the deposition densities on the vertical and horizontal surfaces. At the same time, it can be said, with more certainty than is permissible with the data provided by microscope analysis of slides, that within the limits of 5-7 km approximately 10% of the toxic chemical converted to the aerosol state precipitates.

The data presented above show that the MAG aerosol cloud in the first approximation can be viewed as a nonprecipitating admixture. Therefore, the dose data obtained from these tests should be interpreted as a scattering of weightless admixture in the surface layer of the atmosphere [2, 4].

Table 2.

Year	Conditions	x, km	Deposition density, mg/m^2	
			horizontal surface	vertical surface
1963	field	0,2	~5	
		0,5	~5	
		1,0	~3	
		3—4	~2	
1964	forest	0,7	~0,4	
1965	forest and	1	~1	~1
	field	2—3	0,4	0,1—0,2
		3	0,3	0,15
		6	0,2	0,1

The experimentally obtained values for toxic chemical doses are given in Table 3. The first column of Table 3 gives the date of the test and terrain conditions in which it was conducted; the second column shows the distance from which the selection of samples was made; the last column gives the toxic chemical doses in mg/m^3 s. When analyzing the doses it is imperative to consider the fact that the cloud formed by the MAG at the generator outlet has a higher temperature than the ambient air. Therefore, it can rise to a certain height at the start due to Archimedes forces. This is largely noticeable at small distances from the formation line but the importance of this effect decreases with distance from the source. Analysis of the experimental data within the frameworks of the simplest model [2] showed that cloud surfacing at 50 m can lead to a decrease of the dose at a distance of 1 km by one order of magnitude, and at 3 km and further - by no more than two or three times. Precisely for this reason, in our opinion, there is a large scatter in the dose values at short distances and a decrease in this scatter at great distances.

Photographs of the MAG aerosol flow taken from the side show that their upper boundary does not exceed 100 m. If we assume that the flow axis is in the center of the flow visible on the photograph, then a cloud surfacing height value is obtained which is close to the estimate made from the observed scatter of dose values.

Table 3.

Date and test site	Distance to the MAG, km	Dose, mg/m³s	Date and test site	Distance to the MAG, km	Dose, mg/m³s
1963 field			1966 field		
17 V	1	440	30 VI	1,1	100
	2	560	4 VII	4,5	240
	2,5	310	5 VI	1	1000
	3,2	200		6	330
20 V	0,3	140	6 VII	1	130
21 V	1,1	570	9 VII	1	1900
	2,6	490	11 VII	3	570
	4,8	390	12 VII	1	90
24 V	4	360		3	260
	4	480	18 VII	1	1000
26 V	1	1000		1	340
28 V	1	660		4	470
	1	330		3	500
1964 forest					
6 V	0,2	230	14 VII	1	260
			1969 forest		
19 V	0,2	300	4 VI	2	200
20 V	0,15	580		2	360
21 V	1	270		0,7	1600
4 VII	0,7	220	5 VI	2,5	2000
6 VII	0,7	1300		1,1	1500
10 VII	0,7	230	11 VI	1	240
12 VII	0,7	650			
1965 field and forest					
23 V	2	300			
26 V	2,5	340			
28 V	1,5	490			
4 VI	1	140			
19 VI	1	160			
	2	110			

The weak influence of terrain conditions in the tests was no less interesting. Despite the tremendously diverse test conditions in 1963 and 1966 (regarding the plain surface with vegetation less than 50 cm high) and in 1964 and 1969 (a forest with trees up to 20-25 m high) the dose values are close.

In conclusion, it should be stated that all MAG tests were conducted under inversion conditions. For tests performed in the field, the wind speed at a height of 2 m was 1-2 m/s, and the temperature variation at heights of 0.5 m and 2 m was 0.5 to 0.9°C. Even the use of ASO-3 vane anemometers under forest conditions did not allow us to record any directional movement below the

treetops. At the same time, the wind speed above the treetops (about 10 m above the tops of the trees) was about 2 m/s. The normal operational mode for the MAG was approximately 100 g per meter of expanse. All the dose values given in Table 3 refer to this flow rate.

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